MNS® Low Voltage Switchgear

System Guide

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MNS System Guide

This guide is intended to be used along with other publications related to MNS Low Voltage Switchgear, such as:

MNS Service Manual
Erection, Operation and Commissioning
Publication no. 1TGC902006M0402

MNS Safety Aspects
Publication no. 1TGC900009B0201

Further information on the integrated switchgear platform MNS *i*S can be obtained from:

MNS *i*S System Guide
Publication no. 1TGC910001B0203

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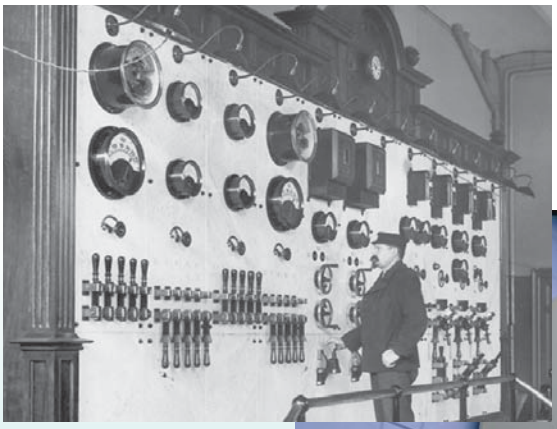
MNS Switchgear Overview

Switchgear Evolution

ABB is the global leader for low voltage switchgear with over 1.2 million MNS cubicles delivered worldwide since the inception of this system in 1973. ABB's history in switchgear can be traced back even further, to the 1890's when we first manufactured switchgear systems in Sweden.

With these credentials it is no surprise that the MNS system is the benchmark for operational safety, reliability and quality.

ABB draws on this wealth of background knowledge in designing and manufacturing low voltage switchgear for its global and local customers. This together with the global service and support network established in over 30 manufacturing locations world wide ensures that the choice of MNS will be the right decision.



Hofors Power Station and Rolling Mill 1890 Sweden

Hospital Zoetermeer, Netherlands

Features & Applications

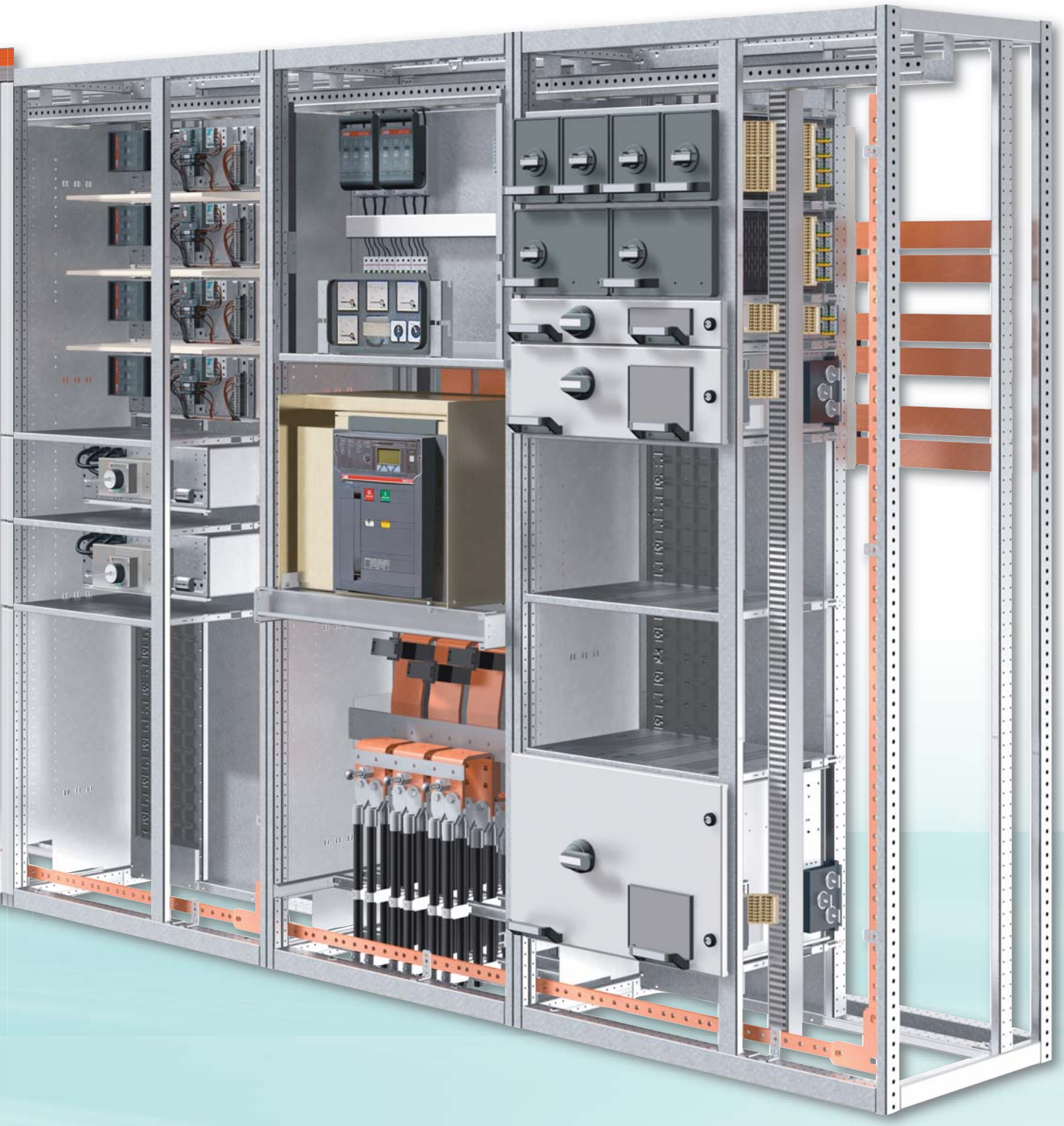
The ABB MNS system is a type-tested switchgear assembly (TTA) in accordance with IEC 60439-1.
The consistent application of the modular principle both in electrical and mechanical design as well as the use of standardized components allows its flexible and compact design.
Depending on operating and environmental conditions different design levels are available.

Notable system advantages with regard to design aspects:
- Optimum protection for personnel and plant
- Fully type-tested including internal arc fault containment
- High operational reliability and availability
- Earthquake-, vibration- and shock-proof designs are available
- Maintenance-free busbar and frame construction
- Simple retrofitting procedures
- Compact, space-saving design
- Simplified project implementation utilizing ABB's dedicated engineering tool

Thus MNS proves to have the approved solution for the following industries:
- Oil & Gas, on and off shore
- Chemical/ Petrochemical
- Pharmaceutical
- Power Stations
- Paper
- Water treatment
- Mining
- Steel
- Food
- Marine

as well as for infrastructure requirements:
- Data centers
- Airports
- Office buildings
- Shopping centers
- Hospitals
- Rail

Typical Set-up



ABB's world wide competence is second to none, this is possible due to the global MNS switchgear platform, and local ABB manufacturing facilities.

ABB ensures conformance to IEC 60439-1 throughout these locations with a proprietary switchgear engineering tool. This tool provides a comprehensive database with predefined engineering solutions for MNS. This database is then utilized with minimal engineering effort to provide customer specific solutions, thus meeting local specifications.

Where specific solutions are required on a global basis, these can easily be deployed throughout the ABB manufacturing facilities network, thus significantly reducing project lead times.

Technical Data

Standards		Type-tested switchgear assemblies (TTA)*	IEC 60439-1, CEI 60439-1, DIN EN 60439-1, VDE 0660 part 500, UTE 63-412
Test certificates		ASTA, Great-Britain (resist. to accidental arcs acc. to IEC 61641 and IEC 60298, Appendix AA) DLR German Research Institute for Aerospace e. V. Jülich, Earthquake Test for Security Areas in Nuclear Power Stations IABG Industrieanlagen Betriebsgesellschaft, Vibration and shock tests Complying with Germanischer Lloyd, Hamburg	
Electrical data	Rated voltages	Rated insulation voltage U_i	1000 V 3~, 1500 V- **
		Rated operating voltage U_e	690 V 3~, 750 V-**
		Rated impulse withstand voltage Uimp	6 / 8 / 12 kV **
		Overvoltage category	II / III / IV **
		Degree of pollution	3
		Rated frequency	up to 60 Hz
	Rated current	Copper Busbars:	
		Rated current Ie	up to 6300 A
		Rated peak withstand current Ipk	up to 250 kA
		Rated short-time withstand current Icw	up to 100 kA
		Copper Distribution bars:	
		Rated current Ie	up to 2000 A
		Rated peak withstand current Ipk	up to 176 kA
		Rated short-time withstand current Icw	up to 100 kA
	Arc Fault Containment	Rated operational voltage	690 V
		Prospective short-circuit current	100 kA
		Duration	300 ms
		Criteria	1 to 5
	Forms of separation		Up to Form 4
Mechanical characteristics	Dimensions	Cubicles and frames	DIN 41488
		Recommended height	2200 mm
		Recommended width	400, 600, 800, 1000, 1200 mm
		Recommended depth	400, 600, 800, 1000, 1200 mm
		Basic grid size	E = 25 mm acc. to DIN 43660
	Degrees of Protection	According to IEC 60529	External from IP 30 to IP 54 Internal from IP 2X
	Steel components	Frame, incl. internal subdivisions	2.0 / 2.5 mm
		Cladding, internal	Minimum 1.5 mm
		Cladding, external	Minimum 2.0 mm
	Surface protection/ Paint	Frame, incl. internal subdivisions	Zinc or Alu-zinc coated
		Cladding, internal	Zinc or Alu-zinc coated
		Cladding, external	Zinc or Alu-zinc coated and Powder coated RAL 7035 (light grey)
	Plastic components	Halogen-free, self-extinguishing, flame retardant, CFC-free	IEC 60707, DIN VDE 0304 part 3
Optional Extras, available on request	Busbar system	Busbars	Fully insulated with heat shrinkable sleeving Silver plating Tin plating
	Special qualification	Test certificates	See test certificates listed above
	Paint	Enclosure	Special colours on request

* Definition TTA: Switchgear assembly corresponding, to a large degree, with the original type or system of switchgear assembly type-tested in accordance with these standards.
** Depending on the electrical equipment

Operational Safety and Availability

The fulfilment of all instructions of IEC 60439-1 assures a basic level for personnel and system protection. With MNS, ABB exceeds these levels as a standard.

The MNS low voltage switchgear system has been subjected to extensive type tests in compliance with the standards. In order to ensure the highest possible degree of safety, ABB continues to conduct tests as per a continuous development program. These tests are based on the most critical representative applications of the entire product or performance range of the switchgear with respect to the test standard. The results of these tests are applicable to the various low voltage switchgear and control gear assemblies (TTA) (in accordance with IEC 60439-1; DIN EN 60439-1 / VDE 0660 Part 500).

In addition to the above specifications ABB adopted as a standard IEC 61641 for testing under conditions of arcing due to an internal fault. To meet the requirements of IEC 61641, the switchgear is connected and supplied corresponding to the normal service arrangement. An arc is then initiated within the switchgear, the point of ignition is chosen to produce the most stress on the assembly. There are five criteria observed for the test, in line with its 'Safety Plus' statement ABB ensures that all five are met. In addition to these five criteria ABB also meets the addition plant protection criteria as detailed in VDE 0660 part 500.

For more information on arc fault containment the "MNS Safety Aspects" brochure delivers essential considerations concerning plant and personnel safety assured by MNS, such as:

- Basic safety philosophy
- Type tested switchgear assembly
- Arc fault protection
- Degrees of protection (IP code)
- Internal separation
- Earthquake, vibration and shock
- Neutral conductor dimensioning

Switchgear Design

Functional Compartments and Segregation

The assembly is divided into compartments thus separating different functional areas.

Incoming circuit breaker solution

1 Equipment compartment
The equipment compartment is divided into 3 sub sections, each sub section having its own door.

The center sub section accommodates the circuit breaker and associated equipment in fixed or withdrawable design.

Depending upon the option for cable entry, for example with top entry solution access to incoming connections is via the door in the upper sub section, the auxiliary compartment is then located behind the door in the lower sub section. For bottom entry the configuration is vice versa.

3 Busbar compartment
Contains the MNS main busbar system. Connection to the main bus is via a 'Partition Plate' with gas sealed connections.

Outgoing solution

1 Equipment compartment
All equipment, including the motor starter modules in withdrawable design, is situated therein. The compartment can be divided into horizontal and vertical* sub compartments.

2 Cable compartment
Contains control cables and terminals, as well as power cables and connection units. Cable entry may be top or bottom.

3 Busbar compartment
Contains the MNS main busbar system. The distribution bars are embedded in the multifunction wall (MFW) which is located between the equipment compartment and the busbar compartment.

* Withdrawable solutions only

Switchboard Arrangements

MNS cubicles can be arranged as follows: free standing, back-to-back or duplex.

Switchboard Dimensions

MNS cubicles have the following representative dimensions:

Mechanical Design

Frame construction

The basic elements of the MNS frame construction are “C” shaped steel profiles with a 25 mm hole pitch according to DIN 43660. This 25 mm equals the dimension of 1E used in MNS to define the area usage within the switchgear.

Each cubicle is precision constructed by bolting horizontal and vertical profiles together, to form a rigid modular structure.
The assembly is maintenance free as a result of the construction method utilizing a combination of thread locking ESLOK screws with bolted pressure plates and thread forming screws.

The profiles are galvanic protected (Zn or Al/Zn) against corrosion.

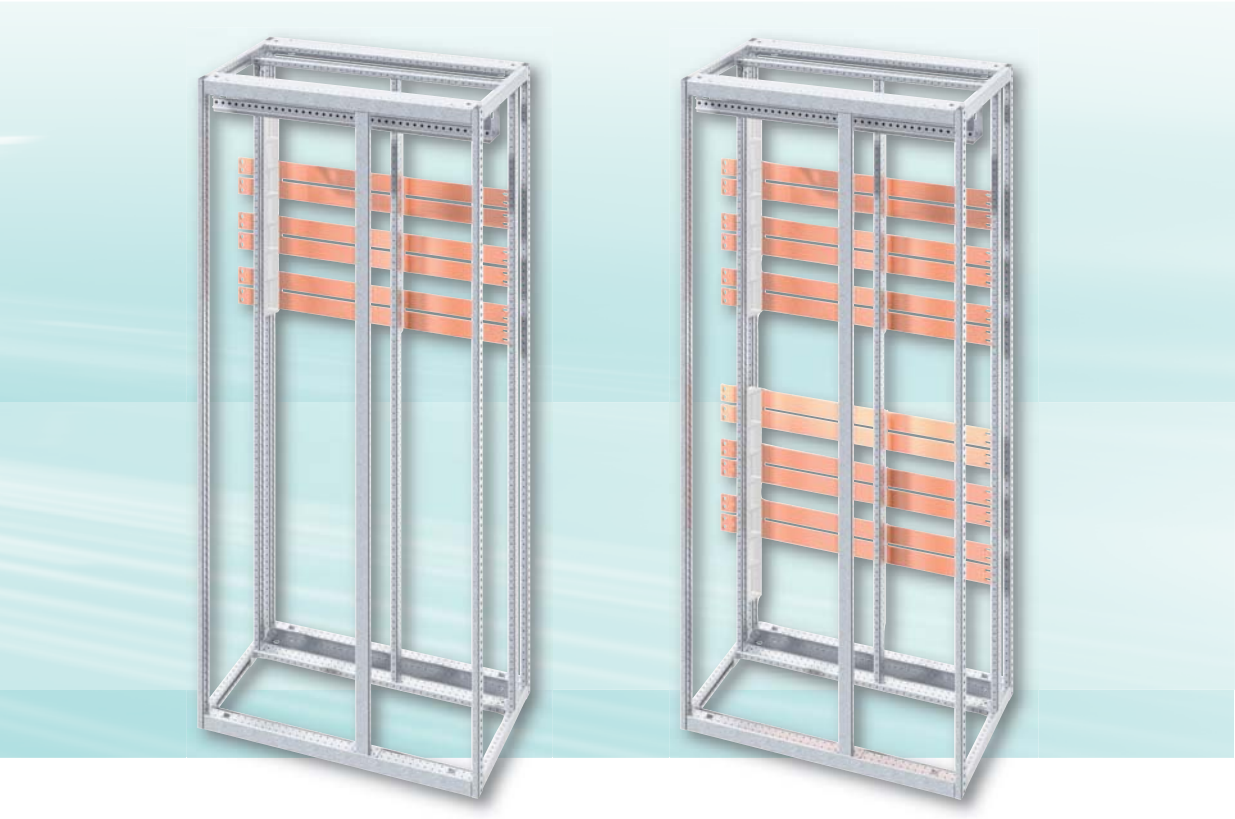
Enclosure

MNS switchboard enclosure is made of sheet steel protected by galvanic coating and powder coating for maximum durability.

The fixing of the enclosure with respect to doors, roof plates, rear and side walls is achieved with thread forming screws. Final construction varies depending upon the required degree of protection.

In accordance with the general safety philosophy followed with MNS, each compartment and sub-compartment which requires access for commissioning, operation or maintenance, has its own door.

Busbar System

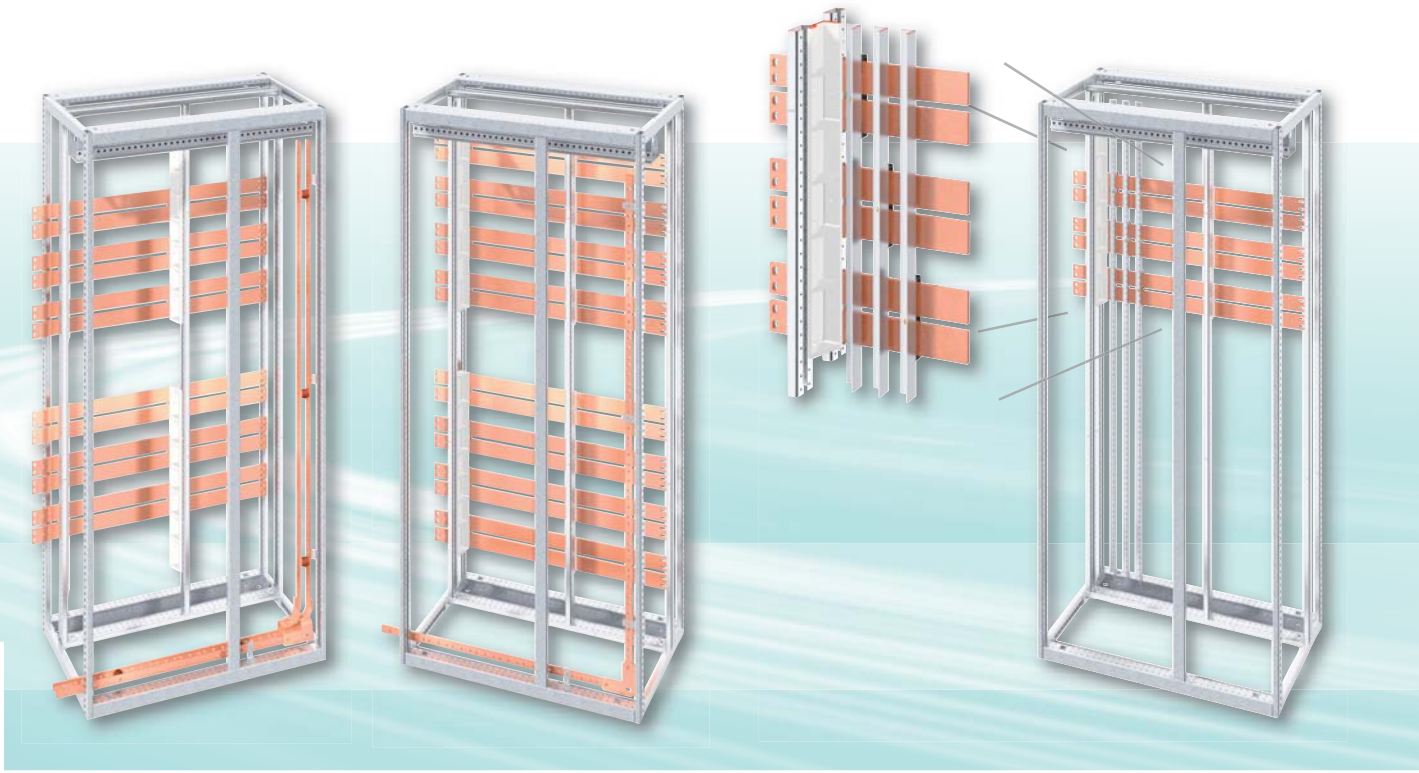


Main Busbars

The MNS main busbar system is arranged in the rear of the switchgear. This assures a maximum distance between the busbars and the operator and maintenance staff. The main busbar system is fully separated from the equipment compartment as well as from the cable compartment.

The busbar system is a maintenance free construction as a result of utilizing thread locking ESLOK screws together with conical spring washers. This technology remains relatively unchanged since the introduction of MNS, and has been extensively supplied into the most demanding industries.

The busbar system and all associated parts are manufactured from copper in accordance with DIN 40500. Options are available for silver plating and/or a fully insulated solution utilizing heat shrinkable sleeving.



Protective Earth and Neutral Bars

As a standard, protective earth and neutral bars run horizontally within the front of the switchboard just above the base. The PE bar is fastened to the frame to assure electrical continuity. Inside the cable compartment they run vertically, located on the front right hand side of the compartment.

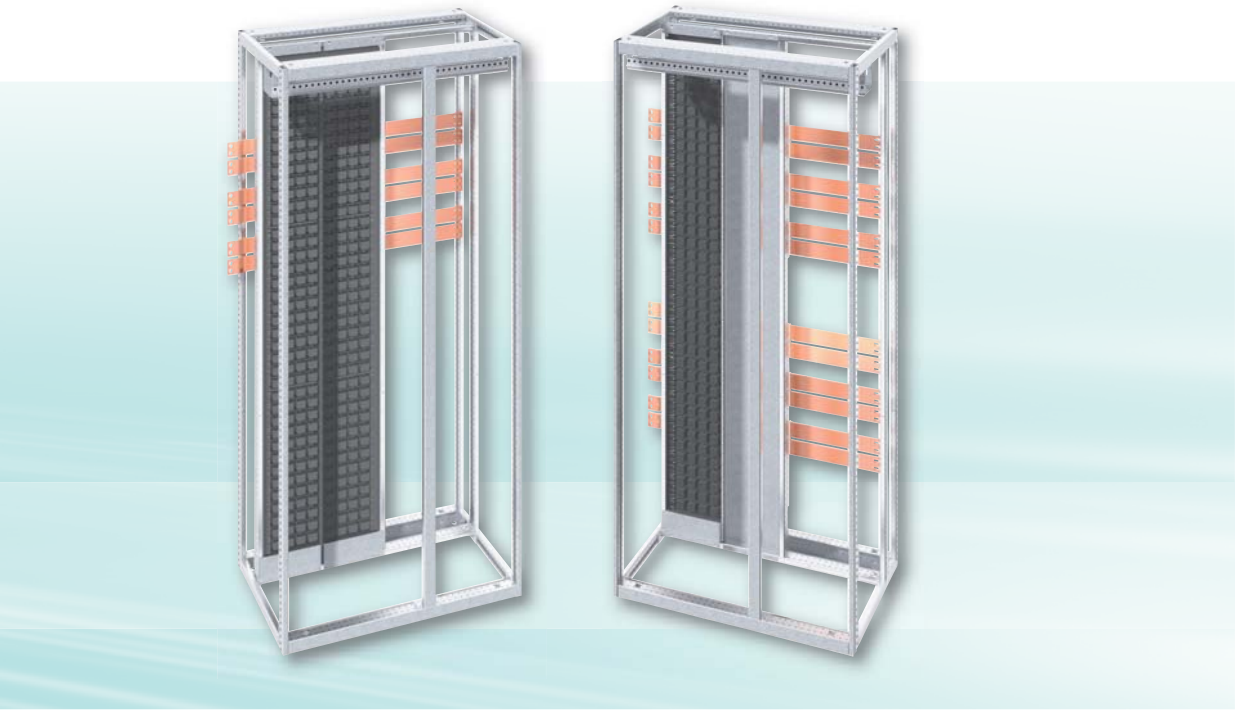
For applications where a 50% or 100% neutral size is required due to unbalance or harmonic distortion as well as for 4 pole switching, the neutral conductor can be arranged within the busbar compartment running in parallel with the main busbars.

Distribution bars

A fully phase segregated and encapsulated 3 or 4 pole distribution bar system runs the full height of the cubicle. The distribution bars are silver plated as standard.

System Highlights

- Maintenance free bus bar construction
- Easy switchgear extension
- Main busbar arrangement at the rear thus assuring
  - maximum safety to personnel
  - effective withstand against highest stresses in case of short circuit
  - optimum heat dissipation
- Gas tight seals for connection from the equipment compartment to the main busbar system
- Option for Form 4 separation for both incoming and outgoing assemblies
- Active and passive arc fault prevention tested according to IEC 61641
- Isolating materials are free of CFC and halogens



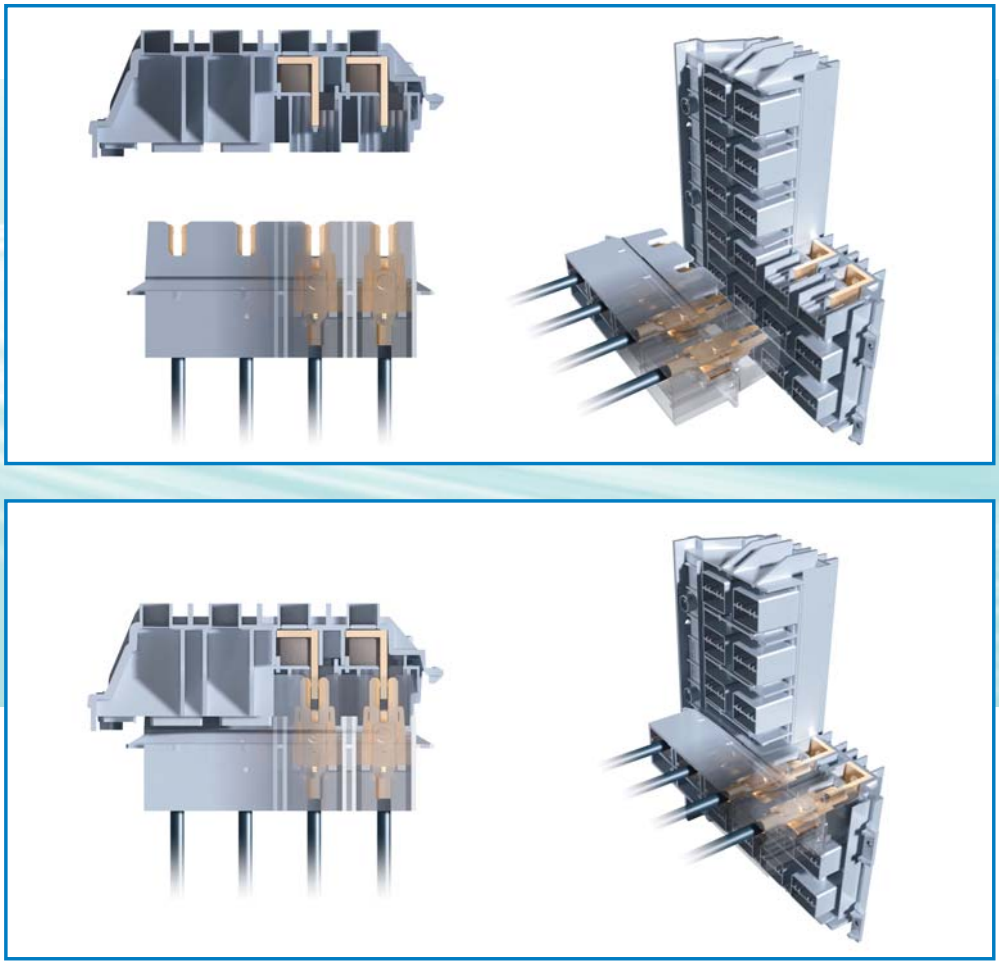
Multifunction Wall

The multifunction wall (MFW) with the embedded distribution bars is a unique MNS design. It constitutes a complete barrier between the main busbars and the equipment compartment.

The distribution bars are fully phase segregated and insulated. This design makes it virtually impossible for an arc to pass between distribution bar phases or between main busbars and equipment compartment.
The insulation material is CFC and halogen free, it is also flame-retardant and self-extinguishing.

Contact openings are finger proof (IP 2X) so that personal safety is guaranteed even when modules are removed.

With the use of MNS specific power contact housings full single phase segregation is assured prior to the connection of the power contacts to the distribution bars.



Power Contact

Connection to the distribution bar is realized using the precision-engineered MNS power contacts. The power contact is characterized by a turnable bearing, thus decoupling cable stress and electrical contact. Consequently any cable bending forces cannot affect the stability of the power contact.

The mechanical stabilisation is achieved by the supporting plate and the contact spring where the contact fingers ensure positive electrical contact. Contact fingers are silver plated as standard.

The contact has been subjected to several tests in order to prove the sophisticated design and the high quality, which provides a life cycle up to 1000 insertions.

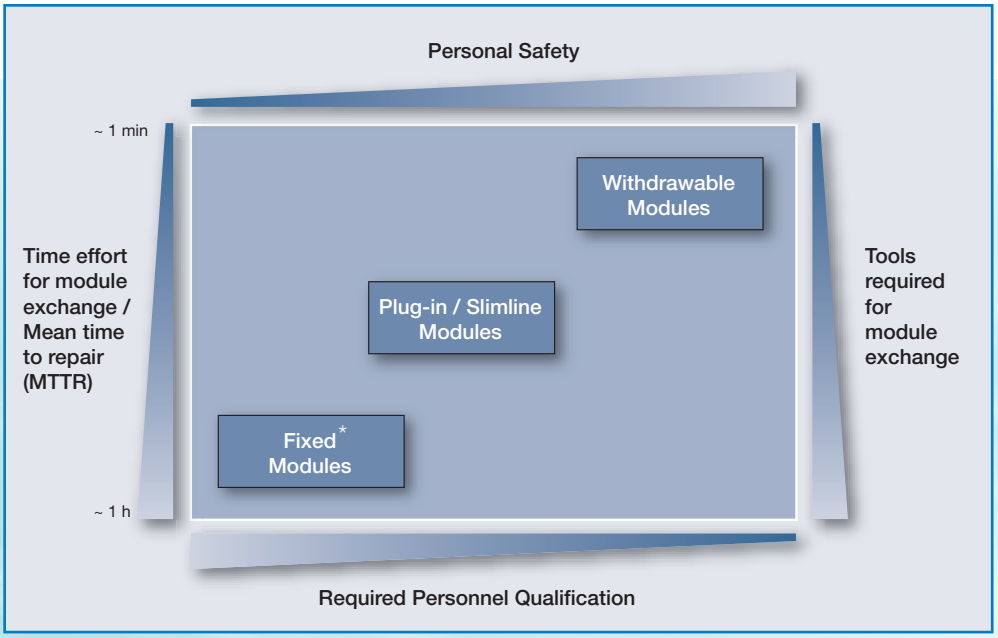
Tests:

- Type test acc. IEC 60439-1
- Corrosion test acc. DIN 50017 and IEC 60068-2-60
- Crimping quality check acc. IEC 61238-1
- Vibration and shock test acc. IEC 60068-2-6 and IEC 60068-2-27

System Highlights

- Operational life cycle up to 1000 insertions (independently certified)
- Bearing construction eliminating cable stress
- Full single phase segregation assured prior to the connection of the power contacts to the distribution bars

Outgoing Modules



* Information on request

The available module types have typical characteristics as shown in the graphic above. Where high process availability is essential and minimal time is required for module exchange the withdrawable solution has proved to be the definitive choice.
In installations where internal access to the switchgear does not present an obstacle the plug-in option may be the practical solution.

Depending upon the choice of outgoing modules selected, the skill set of the personnel required to operate and maintain the switchgear may also differ.

Switchgear requirements differ from project to project. MNS easily allows the assembly to be configured to suit all plant operational procedures.

Plug-in Modules

MNS offer numerous alternatives for plug-in modules. When utilizing the multifunction wall, all modules have the ability to be exchanged without de-energizing the switchgear, should maintenance procedures allow.

The flexibility of the system allows power distribution and motor control to be offered in the most economical Form 2 solution. From this as a basis, options exist for internal/external operation and separation to Form 4.

The Slimline switch disconnector offers ABB's most compact form of fused energy distribution, and is available in 3 or 4 pole options. This design is available in standard modules sizes with a maximum rating of 630 A.

Operation is performed via the handle on the front of the module which has an inbuilt padlocking facility and mechanical open/closed indication.

The following options are available:
- Ammeter
- Auxiliary contacts
- Fuse blown indication

The Slimline is also available as Intelligent Tier Switch enabling the following information to be sent via its fieldbus connection:
- Switch status
- Fuse indication
- Current
- Voltage
- Power & Power Consumption
- Power factor
- Temperature

Plug-in Modules

AC Industrial Drives

Due to its inherent modular design MNS can easily be adapted to house the ABB range of AC Industrial Drives. The switchgear can accommodate multiple drives in a single section. Each drive compartment has an individual isolator, options are available for filters to be installed and for the drive control panel to be door mounted to enable interrogation and parameterization without the need to open the door.

Full size cubicles are also available for the AC Industrial Drives solution. These are, however, of a fixed technique, enabling MNS to offer a complete range of drives all supplied from a common AC bus.

Reactive Power Compensation

MNS also offers the possibility of integrating reactive power compensation modules into its standard design thus reducing the requirements for additional external cubicles.

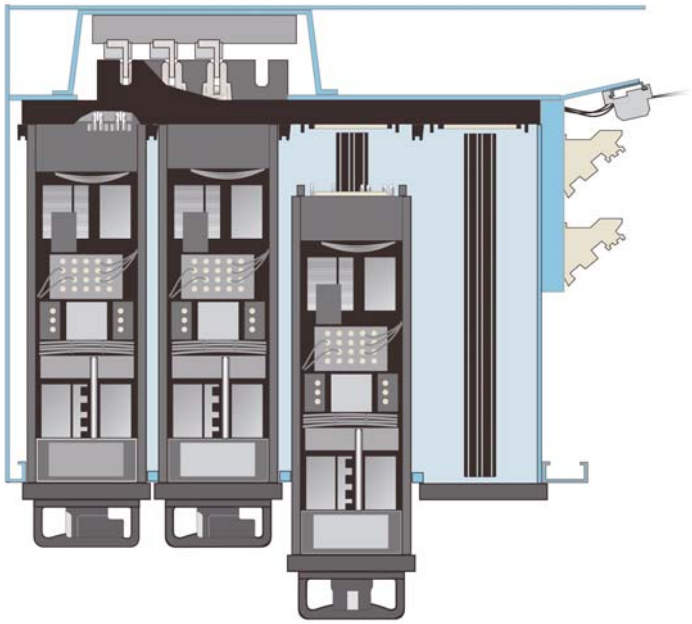
The modular design offers highest flexibility to adjust the compensation power to changes of the load connected to the network.

The standard range covers:
- Network voltages up to 690 V
- 50 or 60 Hz
- All common reactor rates (if reactor required)
- Modules up to 50 kVar
- Controllers available for 6 or 12 step options

Withdrawable Modules

The withdrawable technique has proved to be the appropriate solution for use in industrial applications where requirements for high availability are a must particularly in Motor Control Centers (MCC).

Modules can be easily exchanged under operational conditions thus assuring maximum flexibility.



Small modules

Withdrawable technique is distinguished by its compact design where, with the smallest 8E/4 module it is possible to physically define a maximum of 36 modules in the equipment compartment. This modularity enables the assembly to maximize the usage of the available space, which in turn reduces the overall foot-print of the switchgear.

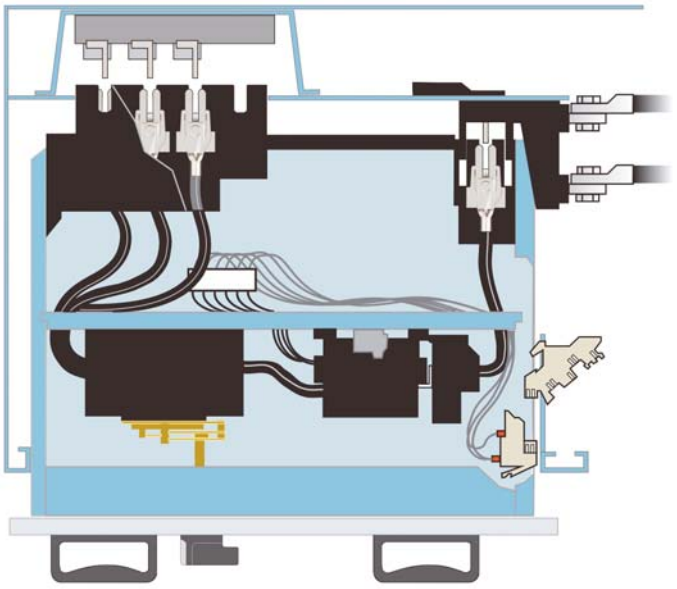
The condaptor unit enables the horizontal distribution of power from the vertical distribution bars, this allows 2 modules (8E/2) or 4 modules (8E/4) to be located adjacently within the same horizontal position in the cubicle. Condaptors are available in 3 or 4 pole options. Cable connections for main and auxiliary circuits are integrated into the condaptor and are accessible from the cable compartment.

Full width modules

These modules are available ranging from 4E to 48E in physical sizes. The construction of the full modules differs slightly from that of the small modules in utilizing a full width hinged door which is mechanically interlocked to the isolator.

All operational procedures for the modules are possible without the need to open the door of the module.

Full width modules connect directly to the distribution bars through the multifunction wall. The design of the module enables auxiliary components to be located on both the vertical and horizontal mounting plates within the module, thus optimizing the available space usage within the module. Cable connections for main and auxiliary circuits are accessible from the cable compartment.



Module operation

MNS modules are operated with the multifunction operating handle. This handle also activates the electrical and mechanical interlocking of the module and the module door. No further tools or unlocking devices are necessary to withdraw a module, thus replacing a module takes less than a minute. Replacement as well as retrofitting of modules can be performed under live conditions, should plant operating procedures allow.

Withdrawable module positions

All main and auxiliary connections are self locating, without the need of additional tools.

ON: Module is inserted, main switch closed, main and control circuit connected

OFF: Module is inserted, main switch open, main and control circuit disconnected, padlocking possible.

TEST: Module is inserted, main switch open, main circuit disconnected, control circuit connected, padlocking possible

ISOLATED: Module is withdrawn 30 mm from the inserted position, main switch open, main and control circuit disconnected, padlocking possible

MOVE: Module may be completely withdrawn from the switchgear

All positions/situations are clearly marked on the fixed section of the operation handle in accordance with IEC 60439-1.

System Highlights

- High stacking density, resulting in a reduced footprint
- Complete phase isolation of main power contact prior to connection to the distribution bars
- Full module functionality with external operation
- Module replacement possible in less than 1 minute, no tools required

Incoming Solutions

All of the MNS incoming solutions are fully type tested in accordance with IEC 60439-1, in addition to IEC 60947-1 required for the individual apparatus, and engineered to meet the requirements of IEC 61641. This ensures ABB's offering of 'Proven Safety Plus' for operators and plant.

Incoming options

All ACBs have as a minimum the following features:

- Manual charging lever and 'Charged' indication
- Manual Open/Close push buttons
- Mechanical 'Open'/'Closed' indication
- Mechanical signalling of 'Overcurrent' release
- 4 auxiliary contacts

Project Specific Options

- Gas sealed connections to the main busbars (separation wall)
- 3 or 4 pole solutions
- Withdrawable/fixed configuration
- Top or bottom cable entry/bus duct
- 50% or 100% neutral
- Shunt opening/closing release
- Undervoltage release
- Electrical signalisation of ACB status
- Key locking facilities
- Shutter locking facilities
- Mechanical indication 'Racked In'/'Racked Out'/'Test Isolated' position
- Locking in 'Racked In'/ 'Racked Out'/'Test Isolated' position
- Switch disconnector option
- ACB handling truck
- Configuration and test unit

In order to satisfy all requirements there are three main switch incoming options:

- Load break switches
- Moulded case circuit breakers (MCCBs)
- Air circuit breakers (ACBs)

Please refer to the technical reference section of this document for a list of related documentation.

Further options available (but not limited to):

- Zone selectivity
- Dual protection settings
- Directional short circuit protection
- Reverse power
- Under-/overvoltage protection
- Annunciation of measured values, alarms
- Maintenance data
- Integration into a plant wide process control system (refer to page 28)

In addition to the above ABB circuit breakers offer a series of integrated programmable releases (PRs), where combinations of protection functions maybe selected with:

- Overload protection - L
- Selective short circuit protection - S
- Instantaneous short circuit protection – I
- Earthfault protection - G

ACB withdrawable operation

In a withdrawable solution the ACB assembly consists of two components, the fixed part (cassette) and the moving part (ACB). This enables the ACB to be located in 3 positions:

CONNECTED: The moving part is fully inserted into the fixed part with the connection of both the power terminals and the auxiliary contacts. The circuit breaker is operational and the mechanical indicator shows 'CONNECTED'.

TEST/ISOLATED: The moving part is inserted into the fixed part without the connection of the power terminals, but with connection of the auxiliary terminals. The circuit breaker may be operated for offline tests. The mechanical indicator shows 'TEST ISOLATED'.

DISCONNECTED: The moving part is inserted into the fixed part without any connection of the power and auxiliary terminals. In this position all electrical operation of the ACB is prevented. The mechanical indicator shows 'DISCONNECTED'. The switchgear compartment door can remain closed, therefore not compromising the IP rating of the switchgear.

The ACB cassette (fixed part) has shutters which are positively driven closed during the racking out process to prevent the possibility of contact with live parts.

Integration into plant-wide Control Systems

System Connectivity Aspects

ABB's structure with respect to offering site wide information is that a field bus connection for process control information and switching commands is utilized. An additional interface, which is typically Ethernet is used to support functions such as parameterization, data distribution to electrical SCADA and/or asset optimization systems. This configuration is also continued through the ABB medium voltage product portfolio.

Configuring the structure as detailed above ensures that the critical process data path is not compromised by also being utilized for parameterization and additional data required for engineering and maintenance.

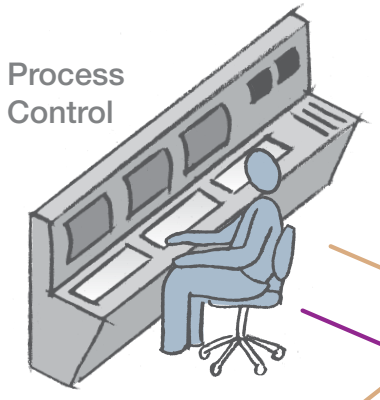
With the introduction of MNS ABB has been providing market leading low voltage switchgear systems technology. In 1987 ABB installed the world's first intelligent low voltage motor control center, since then ABB has delivered over 80,000 intelligent motor controllers.

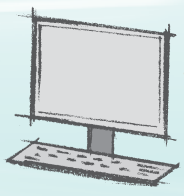
In 2005, MNS *i*S the world's first integrated low voltage switchgear platform was launched. MNS *i*S defines the next benchmark in low voltage switchgear, providing the following features:

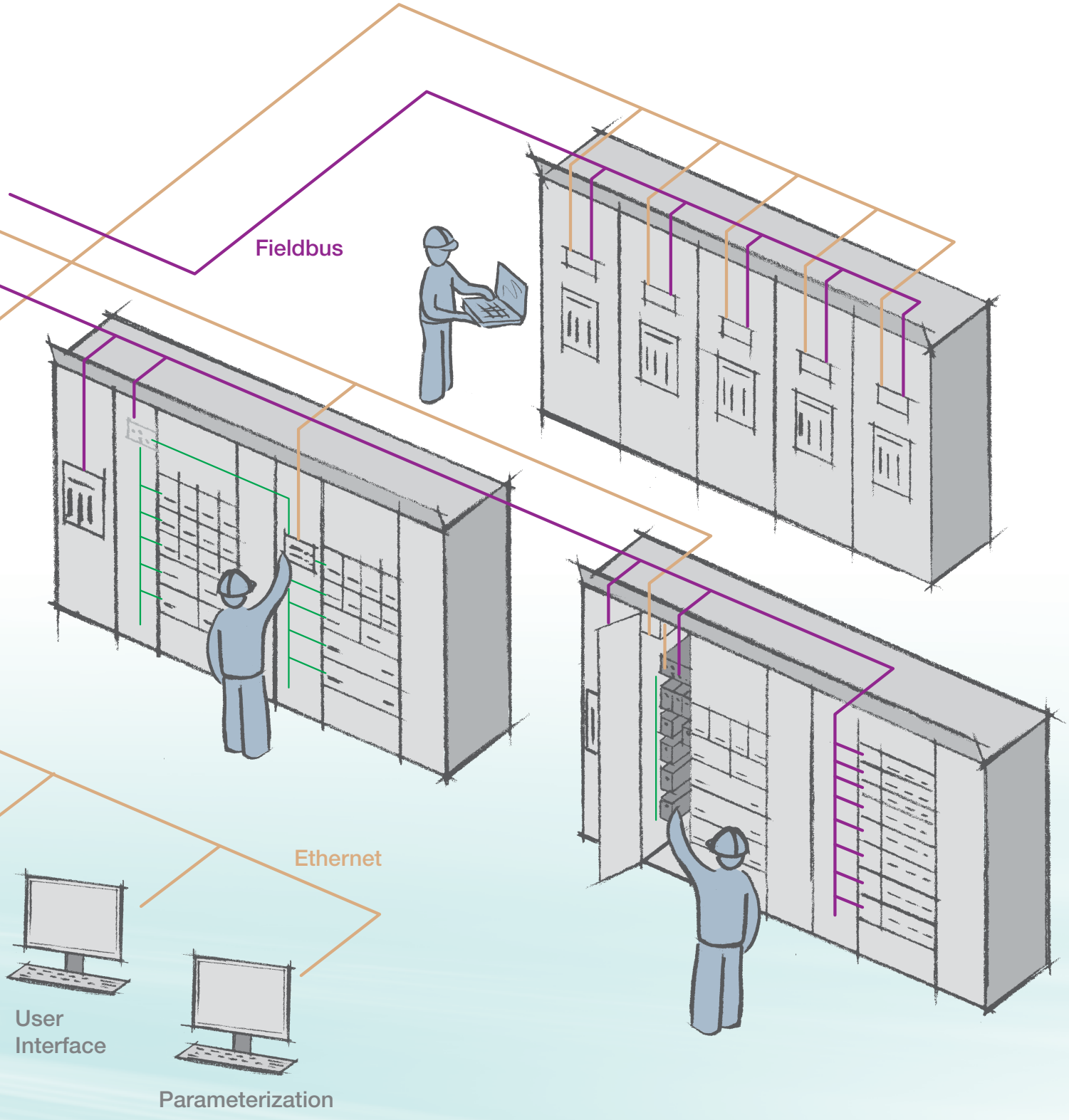
- Improved personnel safety – through a unique design
- Lower life cycle cost – from a totally scalable system
- Worlds first standardised motor controller and feeder modules
- World first self supervising switchgear by the use of asset monitoring
- Future proof, utilizing ABB's patented interfacing technology

The MNS *i*S platform offers in addition to the above the basic characteristics of an intelligent motor control system (IMCS).

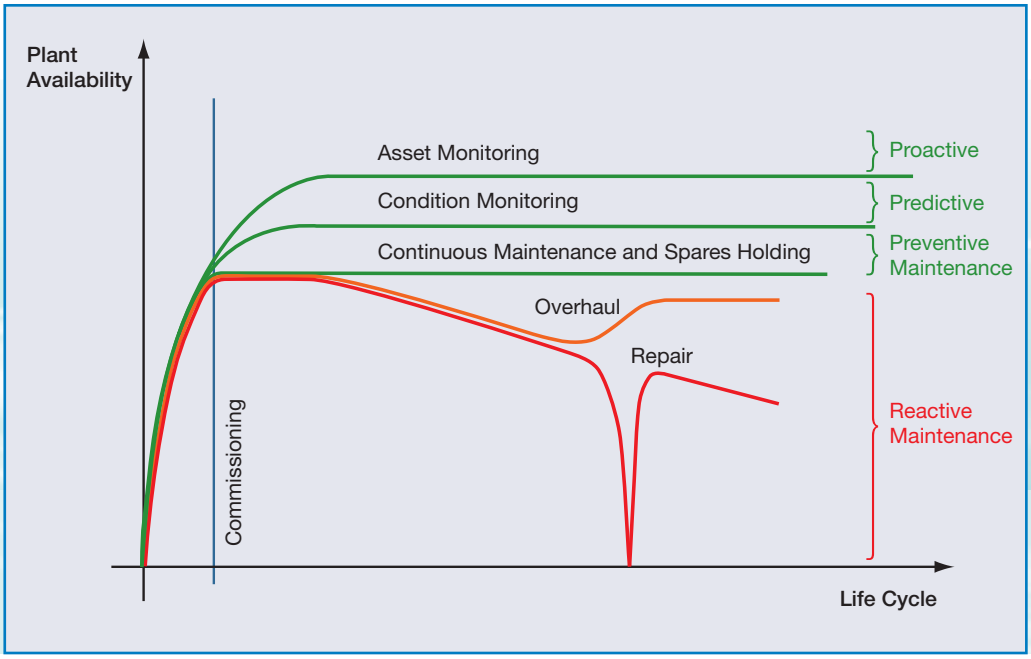
- Micro processor protection monitoring and control of motor and distribution circuits
- Interfacing to host systems via fieldbus communications






Fieldbus
Ethernet
User
Interface
Parameterization

After Sales and Service



ABB's goal is to ensure the assets' maximum performance and availability. ABB has supplied over 1.2 million MNS cubicles from its world wide manufacturing locations. Each of these locations operates with an After Sales and Service department, offering unparalleled global support.

On completion of commissioning, the switchgear is at the peak of its performance. To maintain this condition it is essential to adopt a service and maintenance plan for this asset. If the switchgear does not receive maintenance, this could result in downtime. In production the availability of the switchgear ensures productivity, and any down time is a lost opportunity for profit. Down time can be attributed to the following maintenance practices.

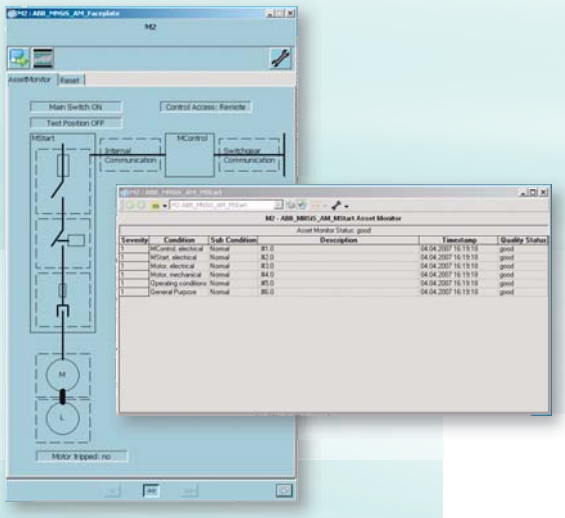
- **Reactive maintenance** is costly for both production and unplanned downtime.
- **Preventive** or **Continuous maintenance** is usually performed on an annual basis, during a scheduled shutdown.
- By evaluating information from the intelligent switchgear it is possible to adopt a **Predictive maintenance** schedule.

Utilizing an ABB expertise can help to increase the life cycle of the switchgear.

Regular Services

ABB offers comprehensive service and support during the whole life time of the switchgear:

- Engineering assistance
- Product training
- Spares holding
- Installation and commissioning
- Service planning
- Hardware and software support
- Upgrades, expansions and modifications



Contract Services

ABB can offer comprehensive maintenance contracts designed specifically for each particular process. Through preventive maintenance programs unscheduled outages can be reduced and maintenance workflows are streamlined.

Utilization of integrated switchgear enables the maintenance to be taken into an even predictive maintenance practice, where information available from the switchgear can further assist with maintenance workflow.

Asset Monitoring with MNS *i*S

In a further step of improving maintenance practices ABB's MNS *i*S platform is a fully self supervising switchgear that can eliminate costs for assets that do not require attention.

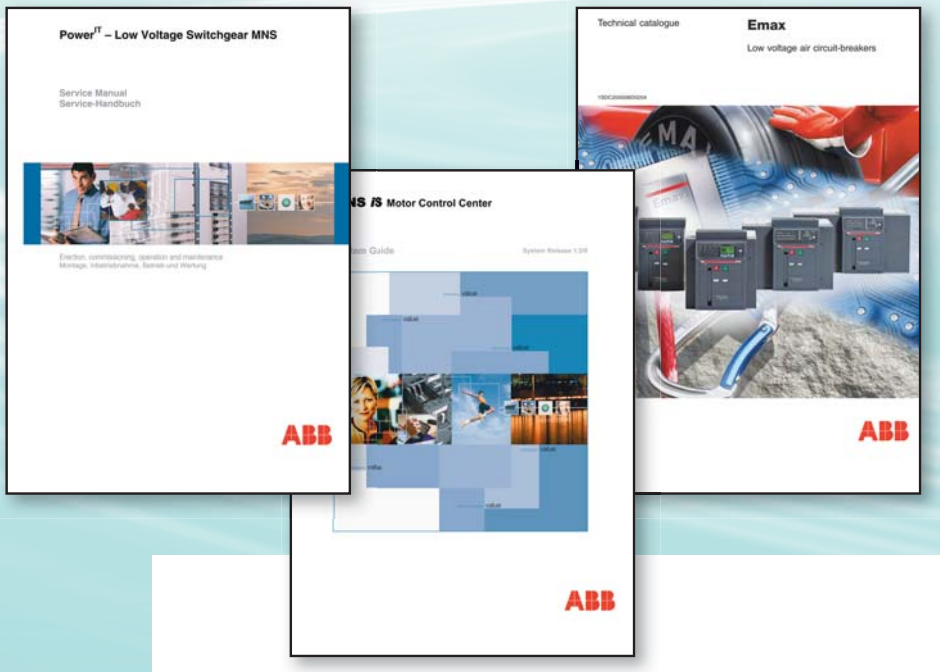
The asset monitor system evaluates all events, alarms and trips for predictive maintenance planning and essential working issues. The conditions are monitored and entered into groups; electrical, mechanical and plant associated. Each condition has a cause and suggested action for problem resolution.

Asset monitoring sets the next standard for integrated maintenance procedures enabling higher switchgear availability through **Proactive maintenance**.

Reference

For more information on MNS, please, refer to the following documents:

No.	Document	Publication No.
1	MNS Service Manual	1TGC902006M0402
2	MNS Safety Aspects	1TGC900009B0201
3	MNS *i*S System Guide	1TGC910001B0202
4	INSUM Technical Information	1TGC901007B0202
5	SACE Technical Catalogue ACBs	1SDC200006D0203
6	SACE Technical Catalogue MCCBs	1SDC210004D0204
7	SACE Technical Catalogue Switches/ Switch Disconnectors	1SCC301001C0202



Annex

The following details are intended as a checklist for the specification of low voltage switchgear.

Items subject to agreement between manufacturer and user

Extract from IEC 60439-1, Annex E

Subclause of IEC 60439-1	Subject
4.7	Rated diversity factor
6.1.1.2 (Note)	Use of ASSEMBLIES in an arctic climate
6.1.3 (Note)	Use of electronic equipment at altitudes above 1 000 m
6.2	Special service conditions
6.2.10	Electrical and radiated interferences
6.3.1	Conditions during transport, storage and erection
7.1.3	Terminals for external conductors
7.2.1.1	Degree of protection required for the intended installation. For floormounted ASSEMBLIES, degree of protection of the bottom to be indicated also
7.4.2	Choice of protective measure against direct contact
7.4.3	Choice of protective measure against indirect contact
7.4.6	Accessibility in service by authorized personnel
7.4.6.1	Accessibility for inspection and similar operations
7.4.6.2	Accessibility for maintenance
7.4.6.3	Accessibility for extension under voltage
7.5.2.3	Values of prospective short-circuit current in case of several incoming units or outgoing units for high-power rotating machines
7.5.4	Co-ordination of short-circuit protective devices
7.6.4.1	Insertion interlock
7.6.4.3	Degree of protection after removal of a removable or withdrawable part
7.7	Form of separation
7.9.1	Input voltage variations for electronic equipment supply
7.9.4, item b)	Supply frequency deviation
8.2.1.3.4	Temperature-rise test for values of test current higher than 3 150 A
8.2.1.6	Ambient air temperature for temperature-rise test
8.2.3.2.3, item d)	Value of neutral bar current for short-circuit test
8.3.1	Repetition of electrical operation test on site

ABB Low Voltage Systems

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